

Towards comparable cognitive creative systems.

Two case studies and a general approach based on cognitive processing, knowledge acquisition and evaluation with human creativity tests.

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Outline

- Human creativity evaluation and evaluation of computational creativity
- Importance of using:
 - cognitively viable processes
 - cognitive knowledge
 - cognitive evaluation
- Two case studies
- Propose a general approach
- Applicability to other creativity tests and cognitive systems

Motivation

- Assistive systems capable of problem-solving tasks & presenting results in a manner understandable by humans (cognitive)
- Artificial cognitive systems can be used to shed light on the human creative problem solving
- Knowledge about cognitive process in human creativity can be used to enable artificial creative systems

Computational creativity evaluation

- Aim to produce artefacts – comparable creativity *result* to that of humans?
- Inspiring set, criteria based on: typicality, quality and novelty (Ritchie, 2001)
- The input, output and process (Pease, Winterstein and Colton); measures of novelty, quality and process
- Others (Colton et al., 2011; Wiggins, 2001)

Human creativity evaluation (I)

- Creativity tests
 - The Remote Associates Test (Mednick and Mednick, 1971);
 - The Alternative Uses Test (Guilford, 1967);
 - The Torrance Creativity Tests (TTCT);
 - The Wallach-Kogan test (Wallach and Kogan, 1965);
 - Insight tests (Maier, 1931; Duncker, 1945)

Human creativity evaluation (II)

1. Solving successfully or not
2. Response time for a particular solution;
3. Difficulty of solving a particular problem item;
4. Fluency;
5. Flexibility;
6. Elaboration;
7. Originality;
8. Novelty - human judges.

Cognitive processes

- Various cognitive processes (analogy, conceptual blending, insight problem-solving)
- Building computational mechanisms akin to cognitive processes
- Such cognitive processes could use:
 - Associations
 - Similarity
 - Structure, context
 - Re-representation

Case Study I – A Remote Associates Test solver

- Remote associates test (Mednick and Mednick, 1971)

CREAM, SKATE, WATER

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ICE

- A computational RAT solver (comRAT-C) (Oltețeanu and Falomir, 2015a)
 - Language data (2-grams)
 - Concepts, Links, Expressions
 - Convergence – creative cognitive framework

Case Study I – A Remote Associates Test solver (II)

- Evaluation with normative data – 144 queries given to human participants (Bowden and Jung-Beeman, 2003)
 - Response times
 - Percentage of solving rates
 - 7s, 15s, 30s allocated solving time
- Performance
 - 97.92% when 3 items known, 30.36% when 2 items are known
 - Other plausible answers; Multiple answers
 - Correlation with difficulty for humans
 - Generative ability

Case Study II - Comparing OROC to the Alternative Uses Test (II)

- The Alternative Uses Test (Guilford, 1967)
 - What other uses can you think of for a *Brick*
 - Evaluation: Fluency, Flexibility, Originality or Novelty
- OROC: Object Replacement and Object Composition (Oltețeanu and Falomir, 2015b)
 - Knowledge base of objects and their properties
 - Feature based creative inference of affordance

Case Study II - Comparing OROC to the Alternative Uses Test (III)

- Evaluation of results as in the Alternative Uses Test
 - Fluency and Flexibility
 - Novelty, Likability and Usefulness (human judges)
- Results
 - Similar to those of humans, process comparable (think aloud protocol)
 - Correlation between Usefulness and Likability

General approach (I)

1. Choosing a human creativity test or a creative problem-solving skill that has some adjacent empirical validation possible
2. Finding a source of knowledge for cognitive knowledge acquisition
3. Implementing a system which uses processes similar to cognitive creative processes
4. Using or obtaining human normative data for that particular test or general task;

General approach (II)

5. Evaluating the results of the artificial cognitive system using:
 - a) human normative data and/or
 - b) evaluation techniques used for assessing the human creativity task
6. Deploying data analysis measures to observe new relations
7. Enabling the artificial cognitive system with generative abilities for that particular test or task (if possible).

Applicability of principles

- General approach – in previous case studies
- General approach – for other creativity tests

Applicability: RAT solver (I)

1. *Human creativity test*: The Remote Associates Test.
2. *Knowledge used*: 2-grams from a human language corpus. *Knowledge organization*: Use of a cognitive framework, Concepts, Links.
3. *Cognitively inspired processes*: Association based search, Convergence.
4. *Normative data used*: Normative data for 144 queries (Bowden and Jung-Beeman, 2003).

Applicability: RAT solver (II)

5. *Evaluation used*: ability to respond to the same queries as the ones in human normative data; correlation between answer probability and human difficulty.
6. *Data analysis*: correlation with human difficulty; yet to be empirically tested on a significant scale: influences of frequency on answer preference. Other measures possible.
7. *Generative abilities*: available => control over frequency, presentation order of items, etc.

Applicability: OROC (I)

1. *Human creativity*: The Alternative Uses Test.
2. *Knowledge used*: Object, Object parts and Features. *Knowledge organization*: Anchoring objects (concepts) in feature maps, ordering feature maps based on feature similarity.
3. *Cognitively inspired processes*: Similarity-based association, structure (transfer), shape bias.
4. *Normative data used*: Evaluation of human answers to the Alternative Uses Test by Gilhooly et al (2007).

Applicability: OROC (II)

- 5. Evaluation:* Fluency and Flexibility; Novelty, Usefulness and Likability (human judges). Comparison of process.
- 6. Data analysis:* Relations between Novelty, Usefulness and Likability. Other possible measures.
- 7. Generative abilities:* offer control over various types of feature influence in creative object use production and creative judgment.

Applicability: The Wallach-Kogan test (I)

1. *Human creativity*: the Wallach-Kogan test.
2. *Knowledge*: Object and Features
Knowledge acquisition: data from human descriptions of objects, crowdsourcing.
3. *Cognitively inspired processes*: Similarity-based association, common parts/structure, feature based search.
4. *Normative data*: Wallach-Kogan – stimuli: often encountered properties and object parts.

Applicability: The Wallach-Kogan test (II)

5. *Evaluation*: Fluency, Flexibility, Novelty, Originality.
6. *Data analysis*: relationships between
 - feature access and component access speed,
 - speed of access and frequency of property (in human answers),
 - Fluency and Novelty ratings, etc.
7. *Generative abilities*: control for frequency of objects-properties or objects-components relations

Applicability: Insight tests (I)

1. *Human creativity test*: Object insight tests.
2. *Knowledge used*: Object knowledge, affordance knowledge, problem templates and heuristics
3. *Cognitively inspired processes*: Re-representation, creation of new problem templates, creation of new heuristics.
4. *Normative data*: some sources exist (Jacobs and Dominowski, 1981), or via new empirical investigations.

Applicability: Insight tests (II)

5. *Evaluation*: comparability to humans in think aloud protocols, the use/creation of similar problem templates, etc.
6. *Data analysis*: problem templates regularly employed, number of associated objects, response times, etc.
7. *Generative abilities*: control over problem templates used or heuristics triggered, objects, features.

Conclusion

- New techniques inspired by human creative cognitive processing
- Comparable systems for cognitive psychologists
- detailed cognitive modelling of creative tasks
- New relations can be observed during the implementation of systems capable of comparable results

Thank you!

Acknowledgements

The support of the Cognitive Systems group at the Universität Bremen is gratefully acknowledged.